

Breeding of a Weak Gluten Wheat Variety Wanmai 788 with High Yield, High Resistance and High Quality

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Abstract Wanmai 788 is a new wheat variety bred by Nanyang Academy of Agricultural Sciences and approved by Henan Province in 2021. This variety is characterized by high yield, multiple resistance, wide adaptability and high quality weak gluten, and is suitable for planting in wheat areas in the middle and lower reaches of the Yangtze River in the central and southern part of Henan Province. This paper introduces the breeding process, characteristics, yield performance and brief cultivation techniques of Wanmai 788, and discusses the key breeding techniques of the variety.

Key words Wheat; Wanmai 788; Breeding

1 Introduction

The perennial wheat sown area in Henan Province is 5 666 700 hm²^[1], accounting for more than 20% of the national wheat sown area. The annual wheat yield in the province is over 6 000 kg/hm², and the annual yield is over 35 million t, accounting for more than 25% of the national total wheat yield. The planting area, average yield per unit area and total yield of wheat in Henan Province rank first in China. The popularization and application of new wheat varieties with high and stable yield is of great significance to stabilize the total grain yield and economic and social development in Henan, and is of great strategic significance to the food security and stable development in China. Wanmai 788 was bred systematically by Nanyang Academy of Agricultural Sciences in 2004 with Yumai 54 with good cold resistance and disease resistance as the female mother, and Zhoumai 16 with large grain and good high yield as the male parent. In April 2021, it was approved by Henan Province (approval No.: Yushenmai 20210032). This variety has applied for the protection of new plant varieties (application notice No.: CNA043406E).

2 Materials and methods

2.1 Test materials The test materials were the new wheat varieties Yumai 54 and Zhoumai 16, the hybrid offspring produced with Yumai 54 as the female parent and Zhoumai 16 as the male parent, and the gradually stable offspring lines. Yumai 54 is a new wheat variety bred by Henan University of Science and Technology, which has early maturity, moderate plant height, good plant type, good cold resistance, moderate disease resistance, more number of ears per unit area, but slightly less ear grains. Zhoumai 16 is a new wheat variety bred by Zhoukou Academy of Agricultural Sciences, and it is a late mature variety, with moder-

ate plant type, large grains and general lodging resistance. The aim of this study was to breed a new wheat variety with high and stable yield, moderate height, lodging resistance, good comprehensive disease resistance and large ears and grains.

2.2 Field design

2.2.1 Single-plant selection. Hybrid offspring adopted plant line planting, 2 lines each plant, 2 m each line; seeds were sown in lines manually at an interval of 10 cm, with a total of 40 seeds, in order to give full play to individual growth potential. The offsprings were cultivated with the best method, and the plants with good performance were retained for planting in the next year.

2.2.2 Product system identification. Under the experimental standard design of Henan Province, the plot area was 1.78 m², and the interval ratio method was arranged in order. A control variety (Yanzhan 4110) was designed every 6 lines. In the yield comparison, the adjacent standard ratio method was adopted, and the yield of every 2 lines was compared with the average value of 2 control lines.

2.2.3 Comparison. Using test standard design in Henan Province, a random area group was designed in an area of 1.78 m², 3 repeats each group, and a control variety (Yanzhan 4110) was set in each repeat. The strain production traits were investigated by analyzing the changes in production percentage of each strain and control via Henan Province wheat varieties area test unified analysis software.

3 Results and analysis

3.1 Breeding objectives In recent years, due to the influence of climate and other factors, the world wheat supply has been in short supply for years, and the resulting food security problem has attracted wide attention from the international community. Therefore, the pursuit of high yield is still the most important goal of wheat breeding in China at the present stage.

Nanyang is an agricultural city with large area of wheat varieties, such as Xinmai 45, Zhoumai 22, Zhoumai 36, Xinong 79, Xinong 585, as well as Cunmai 21, Tianmin 198, Fanmai 8, etc.

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Most of these varieties are half winter varieties, and basically adapt to the ecological environment of Nanyang, with better yield performance. However, the wheat varieties cultivated locally in Nanyang are mostly spring varieties. Although they have certain advantages in disease resistance, they are not outstanding in yield performance. Thus, Nanyang is in urgent need of cultivating a new wheat variety with high yield, high quality and high resistance to fill this deficiency.

According to the utilization status and development trend of wheat varieties in Henan Province, as well as the regional and ecological characteristics of southern Henan Province, we tried to select new wheat varieties with high maturity, high yield, high resistance and high quality based on Nanyang, facing the whole province and radiating the surrounding areas.

3.2 Breeding process In 2004, Yumai 54 was used as the female parent and hybridized with Zhoumai 16. In 2010, 23 strains were selected from F₆ and identified in the next year. In 2013, variety comparison tests were conducted for 2 consecutive years, and 0405-32-34-17-53 with better performance was named as Wanmai 788. The following is the breeding progress of each year.

From 2004 to 2005, the hybrid F₁ generation was planted in 2 m double rows, showing good field performance, moderate plant height, neat ear layer, large grain, large ear, medium disease resistance and medium maturity; the whole single plants in F₁ generation were harvested.

From 2005 to 2010, for F₂-F₆ generation, single plant planting and single plant selection were adopted in a field planting way of 2 m double rows for each single plant. Diversity separation was conducted during this period to select the best among the best, and excellent single plants were selected each year. The field test was dominated by multiple choices, and a batch of single plants was screened out in indoor test and those with good performance were all planted in the following year.

From 2010 to 2012, the strains all had stable performance. In 2010, 23 good plants were selected for interspecific arrangement in the next year, without repetition, and the plot area was 13.6 m². With Yanzhan 4110 as the control variety, the strains were identified for 2 consecutive years, and the plants with poor performance and yield were eliminated, leaving good strains for

strain comparison test.

From 2012 to 2014, the strain comparative test was carried out according to the wheat area test standard of Henan Province. Each test was repeated 3 times, and the plot area was 13.6 m². Yanzhan 4110 was used as the control variety, and 0405-32-34-17-53 with better performance was named Wanmai 788. The strain was selected to participate in the experiment in Henan Province (Fig. 1).

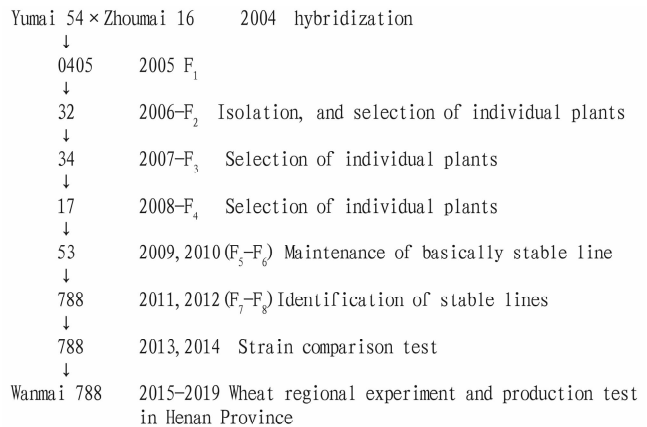


Fig. 1 Breeding pedigree map of Wanmai 788

3.3 Breeding results After 10 consecutive years of field selection and strain comparison tests, a strain with good performance was finally bred in 2014, named Wanmai 788, which participated in the regional test of new wheat varieties in Henan Province, and was approved by the Approval Committee of Major Crop varieties of Henan Province in April 2021.

3.3.1 Excellent agronomic traits. Wanmai 788 is a semi-winter variety, with semi-upright seedlings, thick green leaves, slender leaves, strong seedlings, slow polarization, moderate plant type, flag leaves upward, plant height 77.6 cm, and medium resistance. There are more ears per unit area, and the ear is oblong. Besides, the variety has long awn, white shell, white grain, more uniform and good fullness, showing excellent maturity and comprehensive resistance. The average number of ears was 337 000 – 367 000 ears/667m², the number of grains per ear was 33.5 – 36.2 and the 1 000-grain weight was 35.9 – 44.5 g (Table 1).

Table 1 Summary of traits of Wanmai 788 in trial and production test in Henan Province

Year	Whole growth period//d	Number of basic seedlings × 10 ⁴ seedlings/667 m ²	Number of highest tillers × 10 ⁴ tillers/667 m ²	Percentage of ear bearing tillers//%	Ear number × 10 ⁴ ears/667 m ²	Number of grains per ear//grain	1 000-grain weight//g	Plant height//cm
2017 – 2018	203.4	20.3	73.4	45.9	33.7	33.5	35.9	72.5
2018 – 2019	217.6	20.8	75.8	47.9	36.3	34.5	44.4	77.6
2018 – 2019	212.7	21.1	76.7	47.8	36.7	36.2	44.5	77.6

3.3.2 Ideal quality traits. In 2018 zone test of mixed sample quality analysis (Zhengzhou), Wanmai 788 showed the following traits: protein content 12.3%, bulk weight 707 g/L, wet gluten content 21.8%, water absorption 51.4 mL/100 g, stability time 0.9 min, tensile area 25 cm², maximum tensile resistance 109EU.

In 2019 zone test of mixed sample quality analysis (Zhengzhou), the variety showed the following traits: protein content 13.6%, bulk weight 758 g/L, wet gluten content 28.0%, water absorption 51.3 mL/100 g, stability time 3.8 min, tensile area 37 cm², maximum tensile resistance 159EU (Table 2).

Table 2 Test results of Wanmai 788 in Henan Province

Year	Protein//%	Bulk weight//g/L	Wet gluten content//%	Water absorption mL/100 g	Stability time//min	Tensile area//cm ²	Maximum tensile resistance//EU
2018	12.3	707	21.8	51.4	0.9	25	109
2019	13.6	758	28.0	51.3	3.8	37	159

3.3.3 Good comprehensive resistance. In disease resistance identification in 2017, Wanmai 788 showed medium susceptibility to stripe rust, medium susceptibility to powdery mildew, and high susceptibility to head blight.

In disease resistance identification in 2018, the variety showed resistance to stripe rust, susceptibility to powdery mildew and sheath blight, and high susceptibility to head blight.

4 Outstanding yield performance

4.1 Regional test In 2017 – 2018, through the summary of 8 points in weak gluten group A of the test conducted in southern Henan Province, the increase point rate of Wanmai 788 was 87.5% , and the average yield was 4 530.0 kg/hm² , 7.5% higher than the control Yanzhan 4110 (*P* < 0.01) .

In 2018 – 2019, the experiment continued, and 6 points were summarized. The increase point rate of Wanmai 788 was 100% , and the average yield was 6 408.0 kg/hm² , 8.5% higher than the control Yanzhan 4110(*P* < 0.01) .

In the 2-year regional trial, the average increase of Wanmai 788 was 8.0% , and the average increase point rate was 93.8% .

4.2 Production test In the production test of southern group of Henan Province from 2018 to 2019, the average yield of Wanmai 788 in 9 points was 457.4 kg, and the increase point rate was 100.0% , 8.4% higher than the control variety Yanzhan 4110. There was no pilot with the lodging degree of grade 4 and lodging area of 30.0% (Table 3) .

Table 3 Summary of yield results of Wanmai 788 in wheat trial and raw tests in Henan Province

Year	Variety	Average yield kg/hm ²	Compared with the control//%	Increase point rate//%
2017 – 2018	Wanmai 788	4 530.0	7.5	90
	Yanzhan 4110	4 213.5	–	–
2018 – 2019	Wanmai 788	6 408.0	8.5	100
	Yanzhan 4110	5 905.5	–	–
2018 – 2019	Wanmai 788	6 861.0	8.4	100
	Yanzhan 4110	6 328.5	–	–

5 Key points of cultivation techniques

Wanmai 788 has large grain and medium maturity, and has the characteristics of high yield, multiple resistance, wide adaptability and high quality weak gluten. It is suitable for planting with high water and late stubble in the wheat area of the middle and lower reaches of the Yangtze River in southern Henan Province.

5.1 Fine soil preparation The high water and fertilizer land with the soil fertility level of more than 500 kg can be chosen. After harvest, the previous crops should be prepared promptly and cultivated before sowing to ensure that the soil tillage layer is emp-

ty and solid, so as to improve the quality of land preparation, and further ensure the full, uniform and strong seedlings^[2].

5.2 Timely and appropriate sowing The variety is suitable for early sowing in middle October, and the the quality of sowing should be improved. The number of ears and grains are the main factors influencing wheat yield. Wanmai 788 has the characteristics of medium concentration force, high yield rate, and large grains. Late sowing can appropriately increase the sowing volume, and reasonably grasp by integrating the sowing period, stubble, weather, fertility level and other factors^[3].

5.3 Reasonable fertilization Sufficient base fertilizer must be applied, with reasonable collocation of organic fertilizer and inorganic fertilizer, and the amount of phosphate fertilizer and micro fertilizer should be increased. In the case of sufficient soil moisture sowing, the bottom fertilizer compound fertilizer can be applied at a dose of 1 125 kg/hm² (N : P₂O₅ : K₂O = 17 : 17 : 17) . Compost should be combined with pouring green water. Urea should be applied appropriately, and 45 – 75 kg/hm² should be appropriately applied to the plots with poor soil fertility conditions^[4].

5.4 Good Field management Wanmai 788 belongs to the multi-ear and large ear type variety, with medium height and strong lodging resistance. The measures such as cultivating strong seedlings before the winter, and promoting the early emergence of strong seedlings after the year should be implemented. Topdressing should be carried out in the early jointing or booting stage, accompanied by pouring jointing water and grouting water. Plant height control and lodging prevention should be concerned. In the middle and late stage of grouting, potassium dihydrogen phosphate can also be sprayed on the leaves to prevent dry hot air and increase the grain weight^[5].

5.5 Prevention and control of diseases, insects and weeds Underground pests are mainly controlled in the early stage to ensure that the whole seedlings are strong. Before sowing, it is necessary to treat soil and seeds with agents. Chemical weeding should be conducted promptly. In the middle and late period, it is important to do a good job of one spray and three preventions, paying attention to control aphids, armyworm, starscream, *etc.* , as well as stripe rust, sheath blight, gibberellic disease and other diseases promptly^[4–5].

5.6 Timely harvest The variety is artificially harvested at the end of wax ripening, and mechanical harvest is adopted at the completion period. After harvest, timely drying, clean and storage should be done successively. The variety should be promptly harvested in case of rainfall during harvest period, and timely drying should be conducted when the weather clears up to prevent ear germination and grain mildew^[6].

6 Discussion

6.1 Adhering to the principle of complementary parental advantages The varieties that have been approved by Henan

